

AN ADDITION TO THE AMPHIBIAN FAUNA OF CALIFORNIA

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ABSTRACT.— A population of salamanders of the genus *Ambystoma* has been found at Grass Lake, Siskiyou County, in Northern California. A five-year study has established that the salamanders are reproducing successfully and may represent a relictual population of native amphibians. The Grass Lake area has a sparse human population, which may help to explain how this secretive amphibian could have escaped notice. Attempts to determine the taxonomic position of the Grass Lake salamander, through comparisons of body measurements and coloration with those of other western ambystomatids, were inconclusive. These comparisons suggest, however, a close relationship with the geographically most proximate subspecies, *A.t. californiense* Gray and *A.t. melanostictum* Baird. Grass Lake is near the midpoint of a gap area of approximately 800 km that separates these subspecies. Regardless of the origin of the population, it must now be listed as an established addition to the amphibian fauna of California.

An adult ambystomid salamander was collected at Grass Lake, Siskiyou County, California, on 19 October 1969. The specimen was tentatively identified as a California tiger salamander, *Ambystoma tigrinum californiense* Gray, though its coloration and location more than 500 km north of the northernmost portion of the known range of this subspecies in the San Francisco Bay region did not strongly support this identification. Large numbers of these animals were observed three days earlier by Mr. John Q. Hines, a long-time resident and naturalist in the area. This was the first time that he had seen salamanders at the lake. The animals were crossing the road, moving away from the lake during the first heavy rain of the year.

The California tiger salamander occurs in central California, west of the crest of the Sierra Nevada from Sonoma County in the north to Santa Barbara County in the south (Stebbins 1966). It is found in foothill and valley grassland habitats from near sea level to approximately 1200 m elevation. The California form is distinguished from other western subspecies by its distinctive color pattern of oval, or bar-shaped, white, cream, or yellow spots on a black background color. It is isolated from the others

by great distances, there being no representatives of the species known from the western part of the Great Basin south of the Columbia River area or in the Sonoran Desert.

The northern Great Basin, however, is occupied by the subspecies *A.t. melanostictum* Baird whose nearest populations along the Columbia River are found approximately 432 km north of Grass Lake. The coloration of this subspecies differs considerably from that of the Grass Lake animal.

The Grass Lake discovery initiated a five-year study of the area from October 1969 to October 1974, during which time many additional individuals were found. This paper reports the results of that study and attempts to elucidate the circumstances which could have permitted the undetected existence of such a large amphibian in the area. Comparisons of morphological data with those of other western subspecies of *A. tigrinum* are presented to suggest possible taxonomic relationships.

HABITAT

Grass Lake is at an elevation of 1555 m in a shallow depression between Deer and Goosenest Mountains in the Cascade Range of northern California. U.S. Highway 97

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crosses the lake approximately 34 km north-east of the town of Weed, California. This two-lane highway, built across the lake on a bed of earth and volcanic rock, was completed in May 1932 (Anonymous 1932a). It is a well-used roadway between central California and southeastern Oregon and carried 100 to 300 vehicles per day from its earliest days (Anonymous 1932b), a figure greatly exceeded today.

A rail line parallels the southern margin of the lake with a spur northward into the lake for a short distance. This spur was probably used to obtain water for steam engines, and a small area immediately around its terminus was dredged to a depth of 1 to 2 m, forming a basin which held water in all months of the year since its construction in September 1906. Except for a small cattle ranch and highway maintenance and U.S. Forest Service stations at the western end of the lake, there is no nearby human habitation.

The size of the lake varies greatly, depending upon seasonal precipitation and the flow of two small streams, Bear Wallow and Dairy Creeks, which empty into its northern side. When filled by spring runoff, the lake, situated in a closed basin, measures 4.25 km along its east-west axis, 1.75 km at its widest point. Its contour is very regular, except for the dredged area near the rail spur, which has a maximum depth of 1.5 m. The shoreline slopes gently into the lake around most of its perimeter.

The level of the lake can be controlled by regulating the flow of water into a volcanic vent, approximately 6 m in diameter, situated near the south-central shore. This drain has been encircled by an earthen dam to prevent natural drainage. The dam is breeched at two points by ditches which, when opened, can drain the lake completely to permit the grazing of cattle. The presence of this vent indicates that the lake may have formed in the remains of an old volcanic caldera. Attempts to trace the route of the effluent from this vent, using marker dyes, were unsuccessful.

Much of the lake bed supports a dense growth of tule bulrush, *Scirpus acutus*, which attains an average height of about 1 m. When the lake is drained, a mixture of

native and introduced grasses and sedges grow under the Bulrush, providing the primary source of forage for cattle. There are small stands of common cat-tail, *Typha latifolia*, in the extreme western portion of the lake where somewhat deeper water occurs.

A narrow strip of heavily grazed land, grown to grasses and sedges separates the lake from the forested hill sides of mixed western juniper, *Juniperus occidentalis*, and yellow pine, *Pinus ponderosa*. The understory of the forest is primarily rabbit brush, *Chrysothamnus nauseosus*, and manzanita, *Arctostaphylos viscida*.

The lake is used for breeding and nesting by a wide variety of resident and migratory birds. Large wading birds, including the great blue heron and common egret, frequent the lake and probably prey heavily on reptiles and amphibians since there are no fish in the lake.

The Pacific tree frog, *Hyla regilla* Baird & Girard, long-toed salamander, *Ambystoma macrodactylum* Baird, and western toad, *Bufo boreas* Baird & Girard, are found in or near the lake, and the common garter snake, *Thamnophis sirtalis* L., is abundant. The burrows of the meadow vole, *Microtus montanus* (Peale), the western Mole, *Scapanus latimanus* (Bachman), and the pocket gopher, *Thomomys umbrinus leucodon* Merriam, are found around the lake and extend into it when it is drained. The salamanders probably use these mammal burrows as underground refuges.

Climatological data from the U.S. Department of Commerce Weather Station located at the nearby Mount Hebron ranger station indicates that the area has a mild climate for a mountain region. The weather at Grass Lake during this study was characterized by moderately warm summers, with a high mean monthly temperature of 17.3 C in July. The lake basin is subject to intermittent freezing and light snow from late October to early March, with a low mean monthly temperature in January of -4.0 C. Though the mean annual temperature of 6.5 C at Grass Lake did not differ greatly from the 9.0 C temperature recorded at Weed, only 34 km to the southwest, the difference in total precipitation at these two sites is striking. The mean annual precipitation at

Grass Lake during this five-year study was 35.9 cm compared to the 68.8 cm recorded at Weed during the same interval. This variation in precipitation over so short a distance illustrates the tremendous influence exerted over local weather patterns by the 4317 m Mount Shasta. Most of the precipitation falls in the form of rain during the winter and spring months of October through April. Summer thunderstorms account for a small portion of the total but can influence the level of Grass Lake significantly during critical summer periods.

METHODS

Because of the great distance from San Francisco to the study area and the difficulty experienced in finding specimens of the Grass Lake salamander, collecting trips were conducted mainly in October to coincide with the expected fall migration. Table 1 summarizes the conditions at Grass Lake and the collections made during this study. This information is presented to illustrate the difficulty encountered in our attempts to observe and collect specimens from a population we knew existed in the area. These difficulties offer some evidence, we

believe, that this population may have existed, undetected in the area for a long time.

Preserved Material

Preserved material from the Grass Lake population was compared with that loaned by various western university museums. Loan materials were usually of random collections from widely scattered locations and often contained representatives of more than one subspecies of *A. triginum*. For the purpose of this study, unidentified specimens were designated members of a particular subspecies if the collection site was within the range of that subspecies according to the range maps of Stebbins (1966). Figure 1 (modified from Stebbins 1966) shows the areas from which the materials used in this study were collected and the subspecies to which they belonged.

Only data from fully transformed, adult specimens were compared. There was a general paucity of adult material available, with most loan collections composed of a few adults among large numbers of larvae. The difficulties encountered by the authors in obtaining adult specimens from the Grass Lake population suggest the reason for the

TABLE 1. Summary of observations and collections at Grass Lake, Siskiyou County, California.

	Date	Water level	Weather conditions	Specimens collected
1969	October 19	Low	Freezing with snow and ice present	1 (live)
	December 8	Low	Snowing, no ice present	1 (live)
	December 21	Low	Clear with freezing temperatures	4 (live)* 1 (dead)
1970	April 3-4	High	Clear, warm, and sunny	1 (live) 1 (dead)
	October 21	Low	Clear and dry	none
1971	October 22	High	Raining and warm	1 (live)
	October 23-25	High	Snow with melting snow present	1 (live) 1 (dead)
1972	October 13-15	High	Clear and dry, cold	none
	October 27-29	High	Clear and dry, cold	none
1973	October 13-14	Low	Clear and dry, warm	none
	October 20-22	Low	Overcast with freezing temperatures	none
1974	October 27	High	Raining with temperatures just above freezing	27 (live)

*Collected by Dr. John O. Sullivan, Department of Biology, Southern Oregon College, Ashlund, Oregon.

scarcity of adult material in other collections.

Data taken from preserved materials included: total body length, snout to tail tip; snout-vent length, from lower jaw to the

anterior opening of the vent; head width at the posterior angle of the mouth; head length, from the tip of the snout to the fold of skin at the base of the skull; and the position of the eyes, distance between the in-

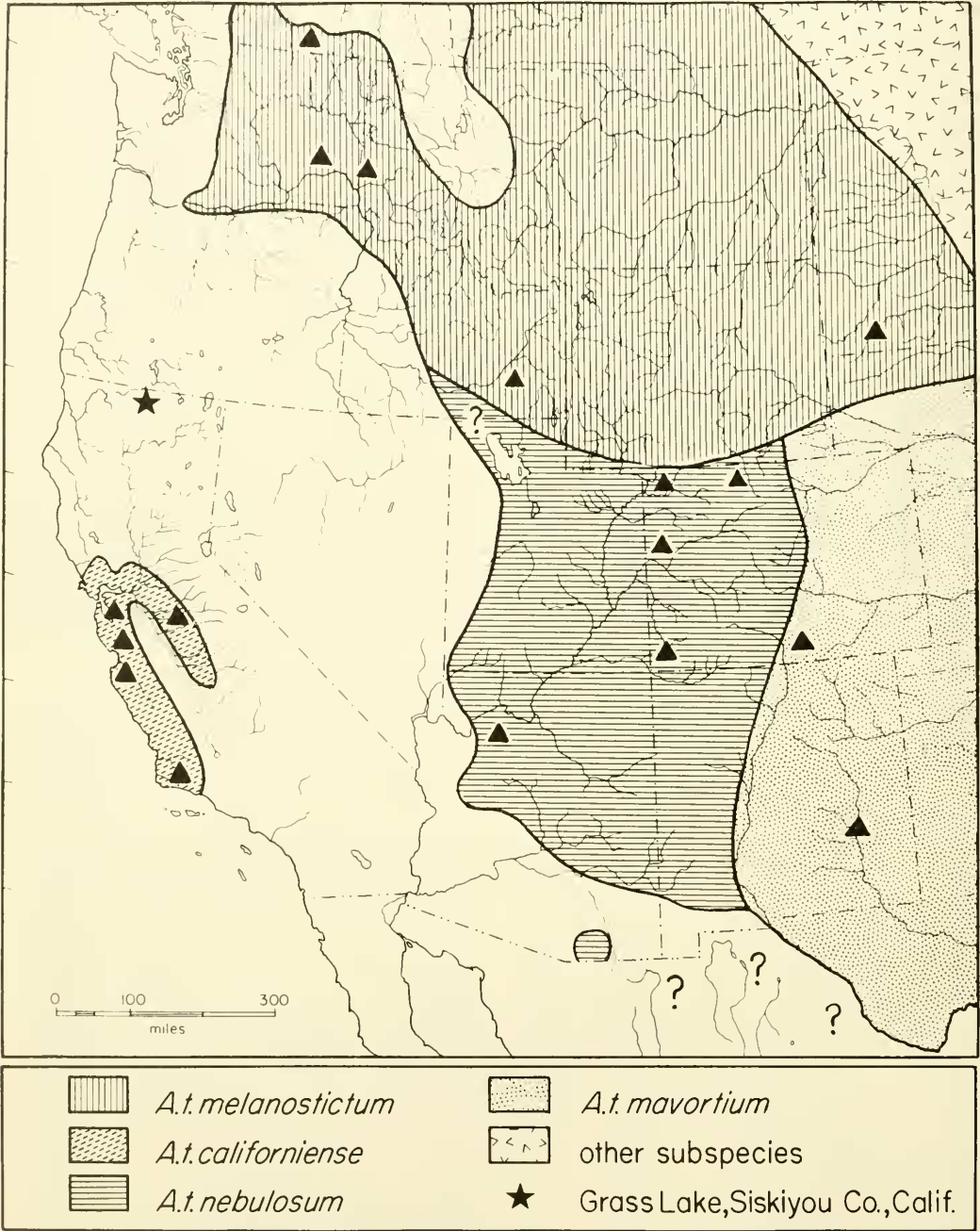


Fig. 1. Map of the western United States showing the distribution of the subspecies of *Ambystoma tigrinum* (adapted and modified from Stebbins 1966.)

nermost eyelid margins. All measurements were taken with calipers to the nearest 0.1 mm. Colors and patterns of coloration were also noted for live and preserved specimens.

RESULTS

BODY MEASUREMENTS.—Measurements for western subspecies of *A. tigrinum* are presented in Table 2. Unfortunately, few adult specimens are available in collections and collecting efforts vary greatly. In southern populations of *nebulosum* Hallowell, for instance, almost all of the adult material available was collected at a single location and time. Allowing for these intrinsic sources of error, however, the Grass Lake salamander seems to more closely resemble the slightly smaller *californiense* and slightly larger *melanostictum* than it does the other geographically proximate subspecies *nebulosum* and *mavortium* Baird. If arranged in ascending order, the various measurements of the Grass Lake sample fall next to those of *melanostictum* in all comparisons and between this subspecies and *californiense* in three of the five comparisons.

The ratios of certain body characteristics presented in Figure 2 are considered more useful as indicators of possible taxonomic relationships because they do not rely on sample size or the uniformity of collecting

efforts. The subspecies are arranged according to their distance from Grass Lake.

The resemblance of the Grass Lake ambystomatid with other western subspecies of *A. tigrinum* is demonstrated. The possession of a slightly wider head with wider set eyes seems to be the only morphologic characteristic examined which might be diagnostic of the Grass Lake form.

COLORATION.—Living specimens of the Grass Lake ambystomatid usually have a black to dark, olive green dorsal, background color which gives way gradually on the lower flanks to a lighter grey-green color on the ventrum (Fig. 3). The background coloration is usually uniform from head to tail on both the dorsal and ventral surfaces and is overlaid by cream-colored, diffusely outlined, irregular spots which tend toward a mottled pattern on the flanks. This pattern extends onto the flanks, belly and gular areas in larger specimens and from the tip of the tail onto the head on the dorsum of most specimens.

Color comparisons of preserved specimens with those of other western ambystomatids, generally considered unreliable because of the variable effects of fixation, did not show any variations which could be considered unique. The Grass Lake salamander resembles *californiense* in the possession of cream rather than black spots, and *mela-*

TABLE 2. Comparison of body measurements taken from preserved specimens of the Grass Lake salamander with those of the western subspecies of *Ambystoma tigrinum*.

Subspecies	Mean measurements in millimeters \pm S.E. (Sample size)				
	Total body length	Snout-vent length	Head		Eye width
			Width	Length	
<i>melanostictum</i>	161.6 \pm 11.3 (13)	80.8 \pm 5.4 (11)	17.9 \pm 1.1 (13)	22.9 \pm 1.6 (13)	8.51 \pm 0.6 (13)
Grass Lake	150.0 \pm 4.2 (30)	77.9 \pm 2.0 (32)	19.3 \pm 0.5 (33)	25.0 \pm 0.6 (33)	8.69 \pm 0.2 (33)
<i>californiense</i>	147.1 \pm 8.0 (21)	77.9 \pm 2.8 (21)	17.5 \pm 0.6 (22)	25.3 \pm 1.0 (22)	6.27 \pm 0.2 (22)
<i>nebulosum</i> , southern	140.4 \pm 2.8 (10)	72.4 \pm 1.0 (10)	16.6 \pm 0.2 (10)	22.9 \pm 0.2 (10)	6.58 \pm 0.1 (10)
<i>nebulosum</i> , northern	188.4 \pm 6.7 (8)	86.0 \pm 2.6 (9)	20.3 \pm 0.6 (9)	27.4 \pm 0.6 (9)	9.27 \pm 0.3 (9)
<i>mavortium</i>	172.6 \pm 13.4 (5)	86.6 \pm 5.3 (5)	20.1 \pm 1.5 (5)	26.3 \pm 1.6 (5)	8.83 \pm 0.6 (5)

nostictum in having mottling on a dark dorsal background. It is also similar to *californiense* in the extent to which patterns of spots extend over the upper body and onto the ventrum and gular regions. Although the individual variation in this characteristic is also great, the typical Grass Lake salamander tends to have a greater number of smaller and more diffuse spots on the dorsum and a more extensive ventral pattern than does *californiense*.

DISCUSSION

The population at Grass Lake is known to have maintained itself for nine years. It appears to be well established and should be listed as an addition to the amphibian fauna of California.

Local residents apparently knew nothing of the existence of salamanders at Grass Lake prior to 1969. One amateur naturalist who had lived at the Grass Lake Ranger

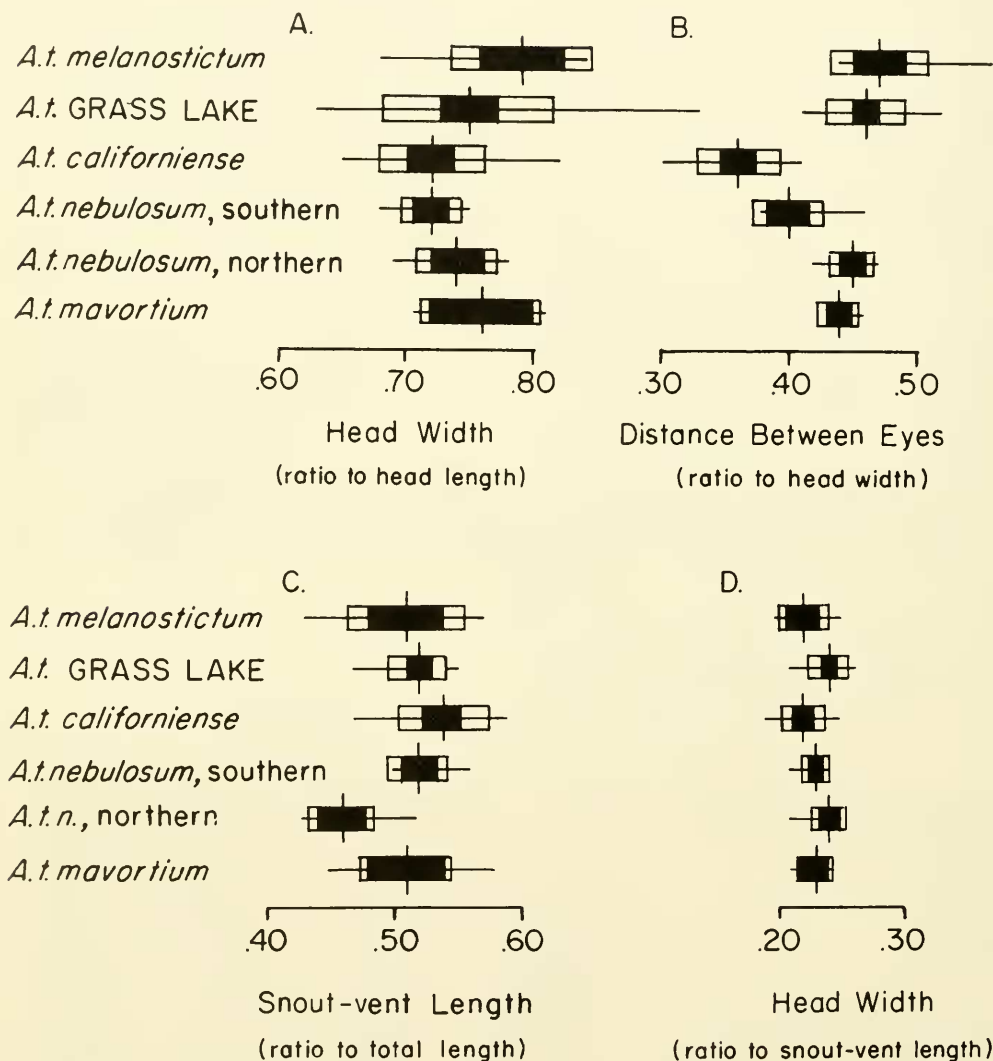


Fig. 2. Morphologic characteristics of the Grass Lake salamander compared with those of western subspecies of *Ambystoma tigrinum*. Horizontal line represents range; vertical line represents mean; open rectangle represents one standard deviation on either side of the mean; black rectangle represents twice the standard error of the mean on either side of the mean.

Station from 1953 to 1960 stated that she had never seen salamanders in the area, nor had she known of anyone who had. She was aware of the existence of a salamander nearer to Mount Shasta, probably *Ambystoma macrodactylum*, known to exist in that area. Other residents reported occasionally seeing "slimy lizards" in creeks which drained into the Klamath River away from Grass Lake. Occasionally caught on baited trout hooks, they were said to resemble mud puppies (*Necturus*) and were probably larval *Dicamptodon*.

A very large number of adult salamanders were first noticed migrating from Grass Lake in the fall of 1969. Reports of hundreds of salamanders crossing the highway from the lake indicate that the population had grown, unnoticed, to a substantial size. The migration is usually completed in a single night during the first heavy annual rainfall and would be observed mainly by

motorists. Unless large numbers of salamanders were on the road, it is unlikely that disinterested motorists would report their presence. The animals blend with the pavement and could easily be overlooked during the hard rains that stimulate migration. Tiger salamanders in semi-arid western parts of the range are subterranean much of the year and are seldom encountered except during their brief breeding migrations. It is thus possible that a relatively large population could have existed in this isolated region for some time without being noticed. We obtained no larvae despite collecting attempts during both summer and winter months; however, our efforts were not intensive.

We have considered the possibility that the Grass Lake salamander was introduced. "Water dogs" had been used as fish bait in Dwinnel Reservoir, a large impoundment about 32 km southwest of Grass Lake. A re-

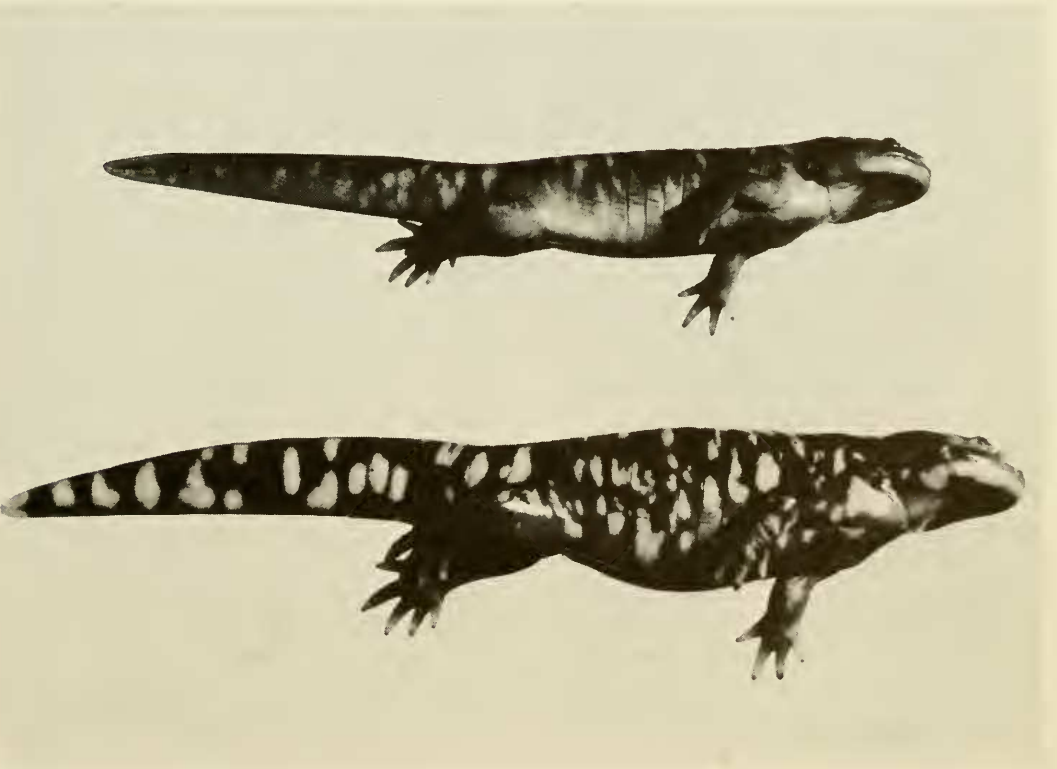


Fig. 3. Living, anesthetized *Ambystoma tigrinum* collected from Grass Lake, Siskiyou County, California. A. MVZ 99976, a 148mm female collected 8 December 1969; B. RCS 11766, a 186mm male collected 19 October 1969.

tailer in Weed stated that the best source of his bait had been a dealer from the state of Washington who had supplied good numbers of gilled larvae described as uniformly dark grey above and lighter grey below. This source was stopped by California authorities in 1965 or 1966. It is most probable that the subspecies involved in these transactions was *melanostictum*.

A second source of "water dogs," described as not having gills and with bright spots on the tail, was from a wholesaler who bought them in Texas or Louisiana. They were not as desirable a bait because they would not swim down into the lake as did the larvae from Washington. This circumstance, plus their much higher price, greatly limited the number imported. California authorities stopped their importation after 1969, though in that year alone the bait dealer sold more than 7,000 of them. It is most probable that the salamanders involved in these transactions were *A. t. mavortium* or the newt, *Notophthalmus viridescens*.

Another bait dealer in Redding, California, confirmed that they too had obtained good numbers of what they called "yellow water dogs" prior to 1969. These salamanders from a Texas supplier were described as about 10–12 cm in length and a uniform light yellow in color. Some had gills and some did not. It is again probable that these salamanders were *A. t. mavortium*.

After the Texas supply was stopped, small numbers of salamanders were obtained occasionally from wholesalers in Nevada. These animals were described as lacking gills and uniformly light grey in color. The subspecies involved in the Nevada transactions could have been *A. t. nebulosum*.

Bait purchased in the Redding area was usually used in nearby Lake Shasta. Very little bait was probably transported the 130 km northeast to Dwinnel Reservoir. Indeed, the great majority of fishermen would have traveled to this lake from the population-dense Redding area and farther south. Surviving baits, not released at the fishing site, would probably have been discarded by fishermen along the road leading from Dwinnel Reservoir to the southwest and away from Grass Lake. Oregon fishermen

from the Klamath Falls area, most likely to use Highway 97 across Grass Lake, probably would not fish in California, where an out-of-state fishing license would be required. These factors tend to minimize the possibility of an accidental introduction of ambystomatids into Grass Lake. There remains, nonetheless, the possibility that the Grass Lake population of salamanders resulted from an accidental introduction of unused fish bait.

The Grass Lake population might have resulted from an increase in the numbers of an ambystomatid native to the area due to recent favorable environmental circumstances. If this is the case, the question remains: why were they not observed prior to 1969?

Access to the area was only possible by a system of unimproved logging roads prior to 1932. Efforts to study the biology of this remote area were probably few prior to this time, and it is possible that these rarely encountered animals could have been present, undetected, or unreported. With the paving of the road came travel across the lake on a daily basis by hundreds of vehicles. This increased traffic, however, would have passed quickly through the area and few travelers would have stopped, as there were no sidings or recreation facilities until the late 1960s. Further, the numbers of salamanders were probably very low and any limited use of the area for recreation would probably not have occurred during the rainy period when migration takes place.

Any discussion of the existence of a previously unknown ambystomatid native to the Grass Lake area, must account for their high numbers in 1969. The dredging and maintenance of the railroad water supply pond may have stabilized and even permitted a gradual increase in the numbers of a small population of salamanders by providing a stable breeding habitat. Later, agricultural practices at the lake, initiated in the 1960s, may have provided the necessary environment for a more rapid growth of the population. When the natural drainage was interrupted, the water level of the basin was significantly altered. This may have dramatically increased the breeding success of the population by providing a large,

stable body of water necessary for increased reproduction while at the same time reducing the success of predators and permitting increased escapement of adults. Successful reproduction in this relatively arid, high altitude location would certainly depend heavily on the conditions at this small, isolated water source. The intervention of man may have proved highly beneficial and resulted in the resurgence of a relictual population.

Evidence from this study seems commensurate with the hypothesis that a relictual population of *Ambystoma tigrinum* has existed, undetected, in the Grass Lake area and that recent manipulation of the lake by man has permitted a resurgence of breeding success and growth of this remnant population. Additional study will be required to clarify its taxonomic position.

ACKNOWLEDGMENTS

We thank the following persons and institutions for the loan of specimens in their care: I. McT. Cowan, University of British Columbia; John M. Legler, University of Utah; T. Paul Maslin, University of Colorado, Boulder; and Richard L. Wallace, University of Idaho. Our appreciation also to Robert M. Winokur, University of Utah, for his generous donation of specimens from

southwestern Utah and to John O. Sullivan, Southern Oregon College, for his provision of additional specimens of the grass Lake Ambystomatid and data concerning their ecology at that site. We also appreciate the opinions of Robert W. Reese, University of Colorado, Colorado Springs, and the time he expended to compare specimens of the new salamander with those in his collection. Finally, our sincerest appreciation to John Q. Hines for his many kindnesses during this study and for his assistance in the collection of field data and specimens from the Grass Lake area, and to Gene M. Christman for preparation of the illustrations.

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